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The Miami Conservancy Bulletin

JUNE 1920

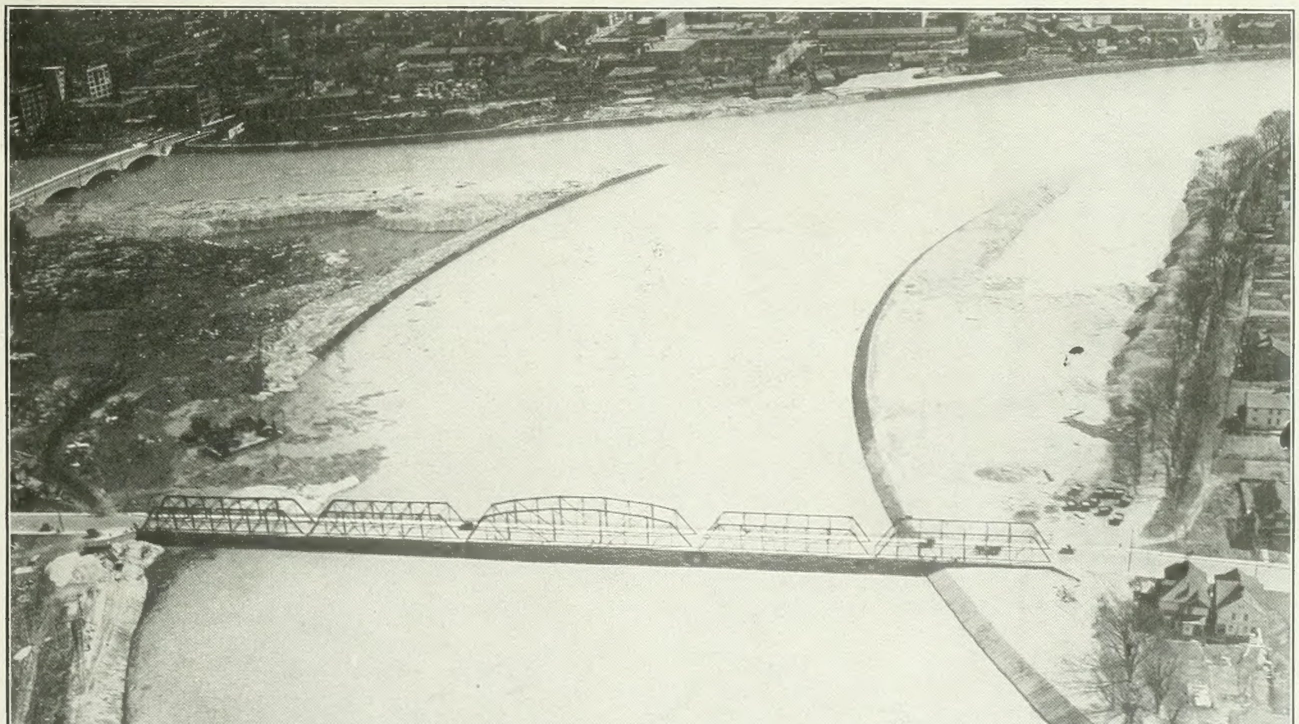

FIG. 137—AIRPLANE VIEW OF FLOOD AT DAYTON, APRIL 21, 1920.

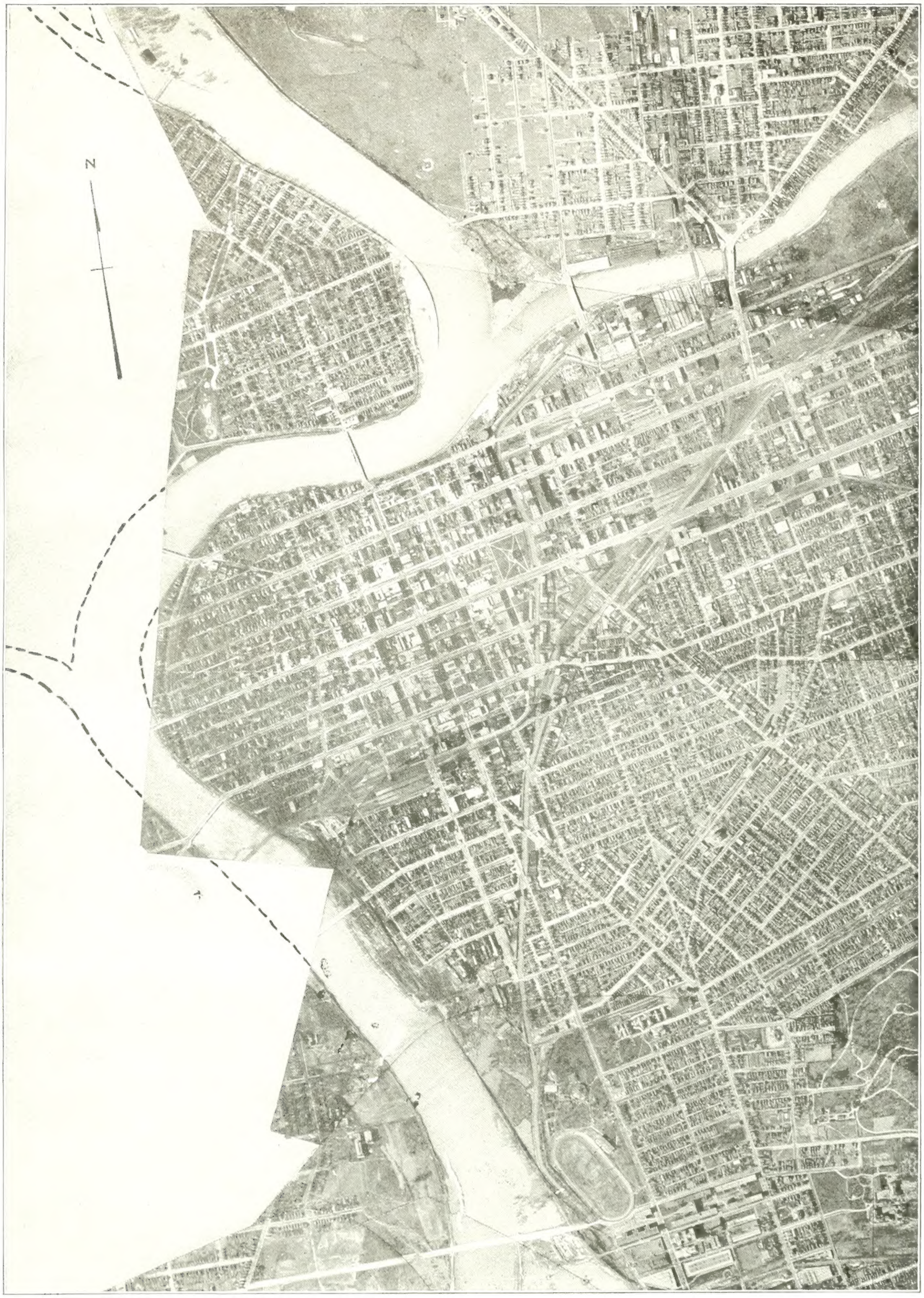

FIG. 138—FLOOD AT DAYTON, APRIL 21, 1920, TAKEN AT 12,000 FEET ALTITUDE.

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Improved Design for Dredge Pump Sump

The attention of engineers is called to the leading article in this issue, by Mr. H. S. R. McCurdy, the Division Engineer at the Englewood Dam, on the new sump design for the dredge pumps, recently put in operation on the work at that place. As he points out, the matter of efficiency, the securing of minimum operating costs, in dredge pump layouts, does not appear to have received the attention it deserves. Where millions of cubic yards of materials must be pumped through such a layout, as at the Conservancy dams, large savings can be made by reducing the various losses, due to friction, drops in velocity, and time lost in shut-downs due to "plugs" in the pipe lines. The Englewood design cuts losses in velocity head. It reduces shutdowns due to plugs, partly by the simple device of putting the pump below water level, partly by the close tab on pipe line pressures given by the simple water level indicator attached to the sump. The simplicity of the design is in fact one of its chief merits. The results attained speak for themselves and are sure to gain the attention of the profession. They give proof that the design marks a distinct advance in dredge pump layouts.

The Flood of April 21, 1920, From an Airplane

The pictures shown in Figs. 137, 138 and 148, in this issue, are of unusual interest. They show how the flood of April 21, 1920, looked as seen from an airplane. They were taken by the photographic staff connected with the United States Army Aviation Station at McCook Field, Dayton, in connection with their regular work in the photographic survey of this vicinity. Fig. 138, on the opposite page, was taken from an altitude of 12,000 feet, and is a part of a map taken during the period of maximum flood, beginning at Osborne, on the Mad River, following that stream to its junction with the Miami at Dayton, and thence following the Miami down to Miamisburg, a total flight of above ten miles. Fig. 138 shows the junction of the Mad and Miami, and the course of the Miami through Dayton from Island Park, in the upper left-hand corner of the picture, down to the Stewart Street bridge, near its lower margin. The arrow at the upper left shows the north point, the picture appearing in the usual orientation of a map. The Mad comes in at the northeast corner. The junction of the Stillwater River with the Miami appears in sketch in the extreme northwest corner. The junction of Wolf Creek with the Miami is seen in sketch at the middle of the western edge. The picture thus brings out vividly the fact of the convergence of floods from these four streams within the limits of Dayton, to which is due the city's peculiar necessities in the way of flood protection. It may help also to show the particularly close dependence of Dayton upon three of the five dams—the Englewood dam on the Stillwater, seven miles to the northwest, Taylorsville dam on the Miami, eight miles to the north, and Huffman dam on the Mad, five miles to the northeast. It shows also the part of the Miami on which much the greater part of the channel improvement is being done. This improvement is nearly completed as far south as Main Street bridge (the first bridge downstream from the junction of the Mad and the Miami.)

An interesting point, which the picture shows clearly, is the method of piecing together the several sections of the map. The photographs were taken in a series of separate, over-lapping shots, in one

flight of the plane down the two rivers. Prints were then taken of the several shots, and pasted together with corresponding parts adjoining, on a roll of detail paper, making thus one continuous chart of the country covered by the flight. The original roll is over ten feet long. The picture is that part of it showing the focus of interest in Dayton. By keeping a constant altitude during the flight (in this case 12,000 feet), the scale of the several photographs remains the same, so that they will fit truly when pasted up. Five separate sections can be distinguished in the picture, the two lower lines of junction being curved to secure closer fitting of the sections to each other. The scale of the picture is about 1530 feet to the inch. Practically, in such photographic surveys, the scale, which is of course determined by the altitude of the flight and the focal length of the camera lens, is more exactly checked by means of monuments which are placed at known points by actual survey on the ground. These monuments appear as white points in the photographs, and, of course, provide an accurate scale if the altitude of flight is maintained uniform. None of the monuments referred to can be pointed out in Fig. 138.

Fig. 137 and Fig. 148 are taken at a much lower altitude than Fig. 138, the elevation in these two pictures being 1200 to 1500 feet. They are single shots, taken with the camera pointing diagonally downward instead of vertically downward as in Fig. 138.

Fig. 137 is taken from a point directly over the Miami River, and looking downstream, with the junction of the Mad and Miami Rivers in the distance. Webster Street bridge over Mad River is at the left, and Herman Avenue bridge over the Miami in the foreground. The smoothness and uniformity of the levee curves, and the smooth junction of the Mad River with the Miami River levee curves at the junction, is perhaps the distinguishing feature of the picture, as related to the Conservancy work. This smoothness and uniformity is to secure corresponding smoothness and uniformity in the flood flow of the rivers, thus preventing the deposition of sediment, and the tendency to ravel the banks where they are irregular. The projecting bank of gravel, showing white just over the left-hand end of Herman Avenue bridge in the foreground, encloses a harbor of refuge provided for scows, etc., in case of just such floods as the picture shows. The steam tug Dorothy Jean, built by the Conservancy forces, and incidentally the only steamer that ever ran on the Miami River, may be seen in the harbor, where she rested safe during the flood. The dark spot just beyond it is a small dragline excavator, which climbed the levee on its caterpillar traction, and thus reached safety above flood level.

Fig. 148 shows Island Park, the principal pleasure park of Dayton, as it was during the flood, with the houses partly submerged. The land here is too extensive and too low to make levee protection worth its cost. Such conditions as are seen occur at long intervals and must be taken as they come. The junction of the Stillwater and the Miami Rivers is in the foreground.

The pictures are published through the courtesy and co-operation of Captain A. W. Stevens, photographic observer, and Lieutenant Lewis McSpaden, pilot, who made the flight when Fig. 138 was taken, and to Lieutenant Goddard, who took the pictures in Fig.s 137 and 148, all three officers being in the United States Army Service at McCook Field.

The Flood at Louth

The people of the Miami Valley can understand better than most others what the feelings of the inhabitants of Louth, in Lincolnshire, England, must have been during the sudden and disastrous flood which swept the town on May 31. As reported in the daily press, it was more sudden than our own flood, the river and drainage area being apparently much smaller, permitting swifter concentration of the water. It was this feature that resulted in the high death toll. People were trapped and drowned in their homes, the sudden weight of water acting to block the doors, so that they could not be opened. Fifty people were reported drowned, most of them in the first few moments of the flood. The disaster should bring home to the people of the District a renewed sense of the value and necessity of our own flood prevention project.

April, 1920, Rainfall Breaks Record

In connection with the flood of April 20-23, it is of interest to note the fact, pointed out by Mr. Ivan E. Houk, the District's Forecaster, in his monthly weather report, that the rainfall over the Miami Valley for the month of April last exceeded by a large percentage the rainfall of any preceding April back to 1893. The maximum prior to 1920, was in the April of 1909, and amounted to 4.62 inches. The total for April, 1920, was about 6 inches, as an average over the Valley. This is nearly twice the average for April during the period, 1893-1920. Most of it fell during the period April 16-21, and it was to this concentration that the crest stage of 16.2 feet in the Miami at Dayton was due, the highest since 1913. The maximum rainfall during the storm period referred to was 6.46 inches, at Bellefontaine. The high April figures for the Valley is the more notable, since April as a rule is a drier month than either March or May.

Drying Out of Flooded Electric Motors

What was said in the last Bulletin about drying out electric motors submerged during the recent flood has attracted some notice, and although the method is not new, a few details may not be amiss.

The two main motors of the wrecked Dayton dragline (see page 174) are of 250 H. P. and 125 H. P. respectively, taking alternating current at 440 volts from a transformer tapped from 2200 volt mains. In wet condition, 440 volts is a somewhat dangerous pressure for the motor coils. Instead, 110 volts are used. To get this pressure, two transformers are interposed between the motors and the 440 secondary: one steps the voltage back to 2200; the other steps it down again to 110, the motors, connected "in cataract," tapping into the 110 volt secondary. The use of two additional transformers in this way is a matter of convenience, the secondary 440 volt cables being right on the ground at the dragline. The current obtained through the motors is about 75 per cent of full amperage, and heats them to 80° or 90° C. The transformers at Huffman were dried in a similar way.

Improved Dredge Pump Layout at the Englewood Dam

Pumps Below Sump Water Level; Suction Pipe in Same Horizontal Line With Return Supply Pipe from Core Pool, With Enlarged Conduit Between, Into Open Top of Which Material Drops from Hogbox.

By H. S. R. McCurdy, Division Engineer

The improved layout can be best understood after a brief description of of Sump No. 1. This was the first of the Conservancy dredge pump installations. In working out its design an attempt was made to incorporate in the layout the best features of existing plants elsewhere. While the general assembly of the plant presented some new features, the various factors in its make-up were in more or less common use. It is shown in Fig. 139.

It has been common practice to set the dredge pump some distance above the level of the water in the sump and to use for priming purposes some form of device which would exhaust the air in the pump chamber, automatically filling it by drawing water through the suction pipe. In sump No. 1 this practice was followed.

It was recognized that bends in either suction or discharge pipe were objectionable, both on account of the increased friction induced by causing the material being pumped to change direction and also owing to the increased wear on the pipes at the bends. To reduce these objections, the suction pipe was fitted from pump to sump with an angle of 45 degrees, rather than with the customary 90 degree elbow. The intake end was cut square; no attempt was made to so shape it as to facilitate the entrance of the material. The discharge pipe left the sump horizontally and contained a 25 degree elbow at the point where it started up the slope of the dam.

The sump consisted of a concrete well, 8 feet square and 10 feet deep, with a flat bottom. An attempt was made to assist the material in flowing to the suction pipe by building wooden sides in the bottom of the well sloping toward the end of the pipe, roughly in the form of an inverted pyramid.

All stones larger than 6 or 7 inches in diameter are liable to lodge in the pump runner, hence must be screened out before the material enters the sump. The first plan for doing this was to pass the material in its course from the hog box to the sump over grizzlies or screens made of steel bars set in 7-in. squares. The services of several men were required to keep the screens from clogging and to assist the oversize rock over the screens and into the bottom dump buckets set at their lower edge.

The installation at Sump No. 1 did all that could have been expected of it. It probably did at least as much work and as good work as dredge pumps in general had been in the habit of doing. But a close study of its operation, with a particular view to power consumption, output and all features entering into the rate of progress and cost of work revealed various possibilities for improvement.

In the first place the sump, or intake well, was not well adapted for passing the material to the suction pipe of the pump. The gravel, sand and clay fell into an inert mass at the bottom of the well and had to be sucked up by the water entering the suction. The materials had a habit of piling up until the mass became so great that a large portion of it would slide down and bury the end of the suction, throwing a sudden throatful of "pudding" into the pump, overloading it, and making a plug in the pipe lines imminent.

Then again the suction was not efficient. The pumps in Sump No. 1 had suction lengths of 18 feet and the center of the suction as it entered the pump was 7 ft. above the water level in the sump. The pump, while operating, showed 16 inches of vacuum, equivalent to 18 ft. of head. The loss of head in the suction pipe was, therefore, about 11 feet. This was due in part to velocity head, and in part to the friction in the pipe, due to its length and curvature and to the shape of its intake end. The net result of this type of sump well and of suction pipe was that unnecessary power was used, progress was limited and plugs in the pipe line were not infrequent. The latter were a particular annoyance, necessitating, as they did, an entire shut-down of the hydraulic fill operations while the pipe line was disconnected and cleared, an operation frequently involving several hours.

Another objection to the first installation was the necessity of priming the pump before starting again, after every shut-down. While ordinarily this was not a difficult operation, occasionally sand would collect in the injector, which would have to be cleaned out. In the aggregate, delays from priming amounted to a considerable loss of time.

As the embankment of the dam reached higher elevations and the length of discharge pipe materially increased, the additional pressures required at the dredge pumps to move the material became strikingly apparent. These high pressures were found to be due, not only to the increased head, but to the

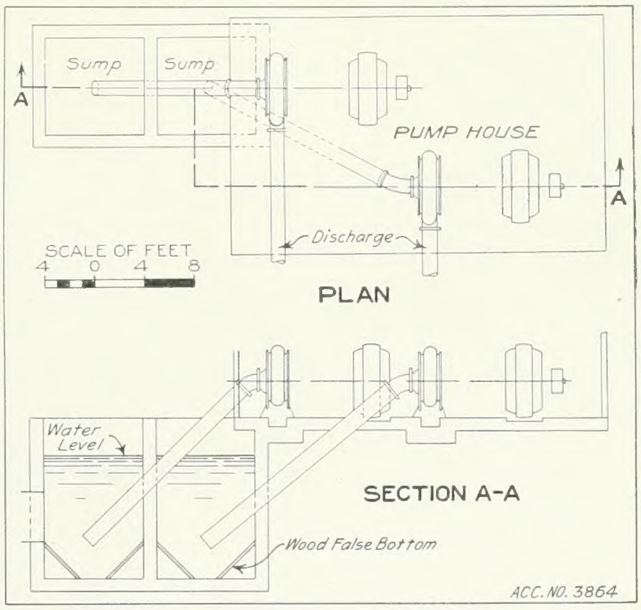

FIG. 139—FIRST SUMP LAYOUT, ENGLEWOOD.

coarseness and gritty character of the material from the borrow pits, which while rendering it excellent from the viewpoint of building a safe dam, gave a very high friction factor and greatly increased the resistance to pumping through long pipe lines. It became apparent, therefore, that it would be expedient to construct additional plants located at higher elevations and closer to the particular portion of the dam each would be called upon to build. With the decision to construct additional pumping installations came the opportunity to incorporate in them such improvements as had suggested themselves in studying the behavior of Sump No. 1. Sumps Nos. 2 and 3 have now been constructed and operated and, as the latter is the latest model, this description will be confined to that layout. It is shown in Fig. 141.

The first radical change, however, came during the operation of Sump No. 1 and consisted of abandoning the use of flat, sloping screens to eliminate the oversize rock and substituting for them cylindrical revolving screens. These screens are 12 ft. long, 4 ft. in diameter, are pierced with 7 in. circular holes and set to a pitch of ½ in. to the foot. They are revolved at a rate of 7½ R. P. M. by 7½ H. P. electric motors. The material enters from the hog box at the upper end of the grizzly, the acceptable sizes fall directly into the sump and the oversize passes to the lower end, from which it drops into a standard 12 yd. dump car to be hauled away. To reach out over the car a 6-ft. extension, flaring to 5 ft. diameter, was put on the lower end of the grizzly.

The position of the dredge pumps was also changed in the later installations. In the original layout the pumps were set 7 feet above the water level in the sump and had suctions 18 ft. long. In the new layout the pump was set 8 ft. below water level. The result is that the pump is always primed ready for operation. The pump suction pipe is straight and horizontal, 5 feet, 6 inches long. At the sump end the entrance to it is given a bellmouth shape to eliminate contraction of the entering jet. The supply pipe bringing the return water from the core pool (the circulation in the pumping layout being a closed system, pumps to pool and back again), is in a direct line with the pump suction. Thus the flow is straight from the return supply into the pump suction. Between the two is a short open topped conduit in line with both, into which the material from the hog box is dropped, as detailed in the next paragraph. Loss of energy at the pump suction is by these means materially reduced, tests showing a loss of head of about 3 feet as against 11 feet in the old sump, a saving of 8 feet. Stated otherwise, and applied to our particular problem here, this means that the millions of cubic yards of mixture of earth materials and water remaining to be pumped will require to be pumped through 8 feet less height.

Another modification of the original plant, in Sump No. 3, was in the design of the sump. In general, the sump is in the shape of an inverted pyramid, collecting the material as it drops from the revolving screen and concentrating it at the bottom. The bottom of the sump is fashioned into the shape of a horizontal circular conduit, 21 inches in diameter, open at the top. One end of this conduit receives the water from the supply pipe and the other end discharges into the steel bellmouth leading to the suction of the dredge pump. It is in its passage through this conduit that the water picks up its load of earth materials. The effect is of dumping sand, gravel, and clay into a swiftly-moving stream of water. The advantage of this method over that originally in use is at once apparent. It will be remembered that in Sump No. 1 the earth materials came to rest in the bottom of the sump and that the suction from the pump was called upon to create sufficient velocity from still water to move this material up into the pipe. And that material had to enter a square-cut pipe end, with all its at-

Details of this are shown in Fig. 142. The part of the discharge which drops nearly vertically from the pipe is sand, which flows in a thin "pudding" along the bottom of the pipe. Larger stones and pebbles which came through are shown piled in a heap in front of the discharge. The discharge at the moment is rather sluggish. A few moments after the picture was taken the pipe "cleared its throat" of the accumulation of sand was shot out two or three times as far as it appears in the picture, knocking the heap of stones down and washing them away down the slope of the gravel beach toward the pool which is seen beyond.

FIG. 140—DISCHARGE END OF DREDGE PIPE LINE AT ENGLEWOOD DAM, APRIL 7, 1920.

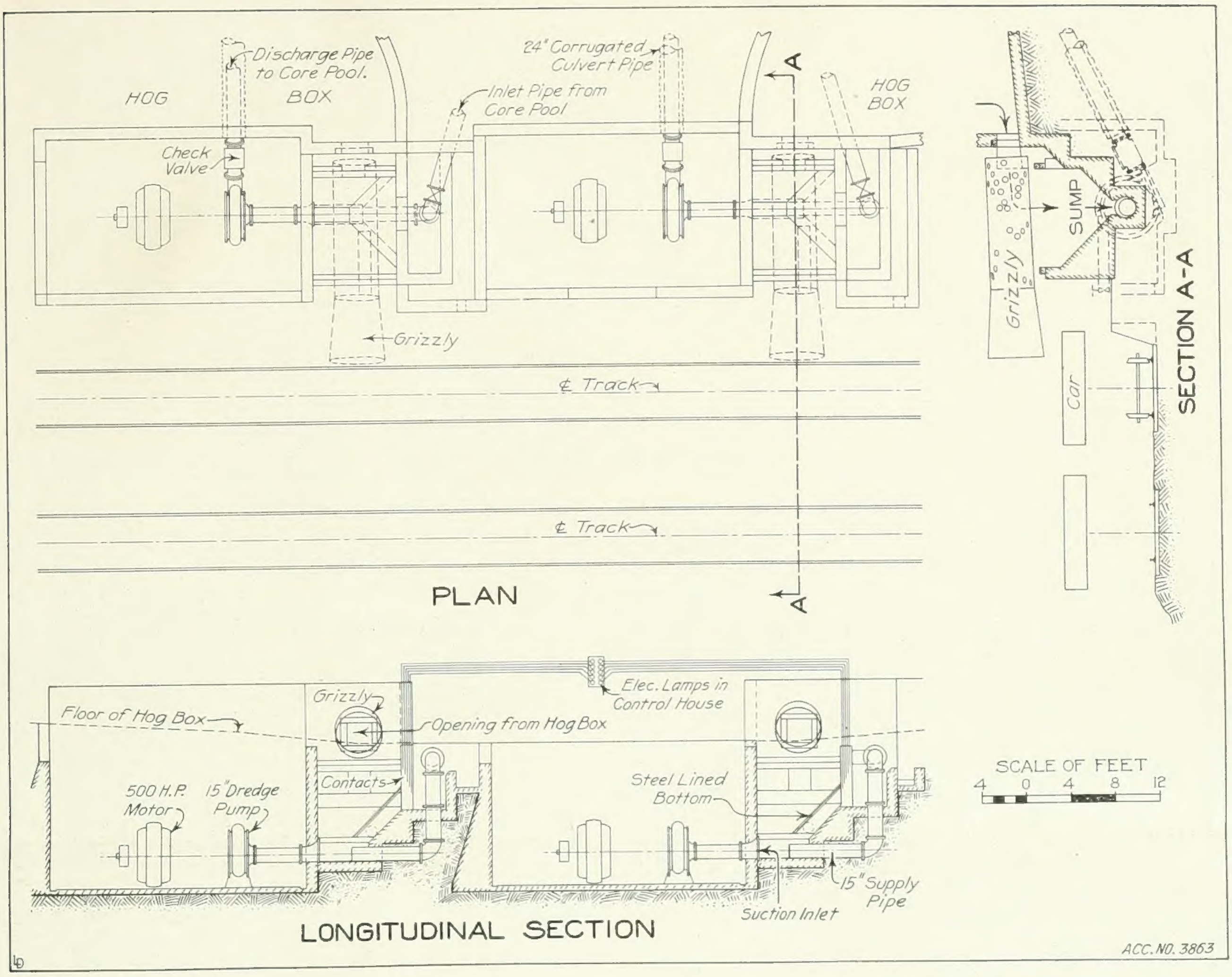

FIG. 141—IMPROVED DREDGE PUMP LAYOUT AT ENGLEWOOD DAM.

tendant contraction losses of the jet. In the new type of sump, however, the supply water enters from the return pipe with a velocity of 10 or 12 feet per second. This velocity is largely conserved in the conduit forming the bottom of the sump, thereby giving the pump just that much of a boost.

In the old layout the discharge pipe left the pump horizontally, necessitating a bend up the slope of the dam. In the new design the pump was set at an angle of 27 degrees with the horizontal, enabling the discharge pipe to be laid without bends. In this arrangement of suction and discharge the only deviation from a straight line occurring in the course of the pumped material from the sump up to the side of the dam takes place in the pump itself, incidental to the centrifugal pumping operation, consequently frictional resistances and wear are reduced to a minimum.

In the operation of a dredge pump discharging through long pipe lines it is of the utmost importance that the pump operator be continually informed as to the conditions of flow in the suction and discharge, with particular reference to the load of suspended materials being carried. Standard pressure and vacuum gages can be relied upon to a certain extent, coupled with an ammeter for electrical consumption, to indicate conditions. The vacuum gage will tell when the suction is becoming clogged. The pressure gage gives warning of heavy loads in the discharge line. But these indicators alone were not sufficient to prevent plugs in the pipe line, as proved time and again by bitter experience. To solve this problem the indicating device described in the caption to Fig. 142 was tried, and proved to be a distinct advance over anything heretofore used. Its operation was very satisfactory, but it involved long electrical circuits running to the ends of the pipe lines, and required removal and resetting for each new length of pipe added. Moreover, it had very little range, indicating only that the actual flow was equal to or greater than a particular discharge for which it was set. How much it exceeded this, or by how much it fell short could not be told at the pumps. At Sump No. 3, however, a device has been put into service which meets the objections to the former indicator and, in addition, gives full information as to conditions at all working stages of flow. It indicates the water level in the sump, and thus the working conditions in the pump line, as follows:

In the design of the plant the size of sump was made such that the water level responds readily to the demands of the pump. In operation, the valve in the return pipe from the core pool is opened to the point giving the proper flow as determined by trial. With an equal feed of solids from the hog box a speeding up of the pump causes a correspond-

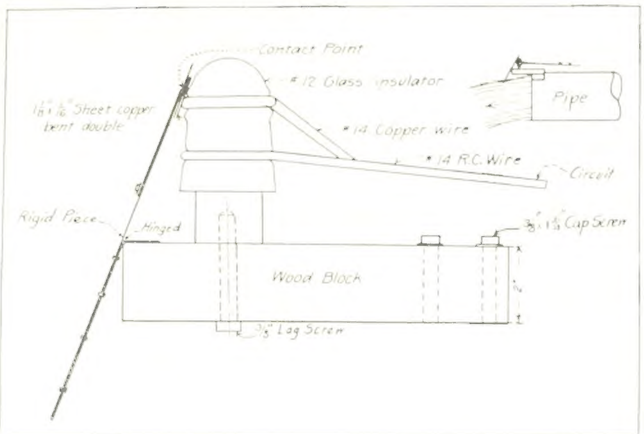

FIG. 142—ELECTRICAL INDICATOR FOR DREDGE PIPE.

Diagramatic sketch of its attachment to the pipe, but not showing the clamps, is shown in the upper right-hand corner. See also Fig. 140, where the device appears turned end for end as compared with this cut. The wood block above is screwed to an iron plate bent to the curve of the pipe end and clamping to it as in Fig. 140. The working piece is the thin diagonal metal plate at the left, hinged to the top edge of the block. The lower part of this dips into the stream discharging from the pipe, as shown in the upper right-hand corner. The force of the stream keeps the upper part of the hinged plate in electrical contact with a metal point attached to the glass insulator. When the discharge slackens the lower part of the plate drops by its own weight and the contact is broken. An electric lamp in the pump house, which is in the electrical circuit, then goes out, warning the pump man that the discharge has slackened to the danger point, indicating an incipient "plug" or stoppage of the dredge pipe by the suspended earth materials which it carries. The pump man then throws more power into his dredge pump motor, breaking up the incipient plug and driving it on to the discharge outlet. This device worked well, but did not indicate how near the critical point of "plugging" had been reached. See page 167. The new system, there described, corrects these shortcomings.

ing lowering of the water level in the sump. Conversely, decreasing the speed of the pump causes the level of the water in the sump to rise. With a constant speed of pump, increased feed of solids from the hog box causes the water in the sump to rise and decreased feed allows it to lower.

In actual practice the pump operator knows that if the water in the sump rises and the pressure gage shows increased pressure, at the same time that the ammeter shows decreased electrical current, his discharge line is being heavily loaded. If, on the other hand, the water level in the sump lowers while the pressure gage shows decreased pressure and the ammeter indicates increased power consumption, then he knows that the pump is handling less solid material. It is upon these phenomena that the warning device is based. It is necessary only to keep the pump man continually informed of the fluctuations of the water level in the sump and, with his gages, he can tell for a certainty what is taking place. The immediate warning comes from the water level in the sump; the gages simply explain the cause of the fluctuation.

It was found by trial that the fluctuations of the water level in the sump for ordinary working conditions were confined to the top two feet. When the sump was full, danger of a plug was impending; when the water level was two feet down from the top the pump was not handling all the solids of which it was capable, and it was up to the monitor men to sluice in more muck. (In practice the monitor men have instructions to flush the material into the sump as fast as they can unless warned off by the pumpman). It was decided that indications of the water level should be shown to the pumpman at 6-inch intervals. To do this 0 gage solid copper wires, 5/16" diam. were suspended vertically, the bottom of one being at the level of the top of the sump, the bottom of another being two feet below the top of the sump, and three others ranged equally between. These wires were connected in circuit with incandescent bulbs in sockets on the control board in the pump house, one above another in the same relative positions as the terminals to which they were attached. To protect the eyes of the pump runner from the glare of the lamps the whole are incased in a box with a ground glass front, the top compartment being red to indicate the danger warning. The top circuit is also connected to a lamp on the giant to give the monitor man warning when the sump is full and feed should be slackened. The arrangement of this device is shown in Fig. 141.

As to the efficiency of the new installation of dredge pumps a few figures may be cited. Last year, from Sump No. 1, the maximum output from one pump in a ten-hour shift was 259 twelve-yard cars and from two pumps in the same time 383 cars. This season, 510 cars have been pumped with one pump in one shift to date, totalling 4,590 cubic yards. The rate of pumping was 58 cars, or 522 cubic yards, per hour, the actual running time being 8 hours, 48 minutes. The amount was limited only by what the draglines could excavate. How much the pumps can handle is not known, excepting that on May 17 one pump operated for 4 hours and 51 minutes at the rate of 64 cars per hour, when the supply of material gave out.

April Progress on the Work

GERMANTOWN

Good progress has been made on the hydraulic embankment during April, except for the delay caused by the high water. During the month 57,150 cubic yards were placed, making a total to date of 499,200 cubic yards. This is approximately 63 per cent of the total hydraulic embankment to be placed.

On April 20, due to heavy rains in the early morning, the creek began to rise very rapidly. By noon the pump houses were practically submerged. The creek continued to rise all afternoon and by night the water stood a foot below the inlet headwall. At the outlet works a very decided hydraulic jump occurred. The total height of the jump was approximately 7 feet. The bridge carrying the dredge pipe across the inlet channel was washed out and considerable drift was deposited about the pump house. The flood delayed pumping operations for five days.

The contract for grading and graveling Road No. 1 was let to Mr. Conley. Work was begun April 24 on that portion of the road south of the dam.

Work was begun by Mr. Daniels on April 26 on the remainder of the excavation in the spillway. This work is progressing satisfactorily.

Riprap is being placed on the upstream slope of the dam above the first berm. The oversize rock from the pumping plant is used for this purpose.

Arthur L. Pauls, Division Engineer.

May 18, 1920.

ENGLEWOOD

Hydraulic fill was continued in the easterly portion of the dam, using Sump No. 2, until May 3. On that date the pumping operations were transferred to Sump No. 3. On May 6 work on the easterly portion of the embankment was suspended and the filling of the old river channel begun. Sump No. 3 has successively broken all previous pumping records. The best performance to date was on May 14, when, with one pump only in operation, 4000 cubic yards of embankment were placed in 8 hours, 48 minutes, a rate of 455 cubic yards per hour. This output is 170 per cent of the best one-pump performance of last year and exceeds last year's best record for two pumps by 15 per cent.

The excavation for the temporary spillway west of the river has progressed favorably. The material is being excavated by a large electric dragline and passed over for use in the center portion of Cross Dam No. 2, along the west bank.

A portion of the covering of clayey earth over and around the arches of the conduits has been placed.

Ten thousand additional seedling trees have been planted in connection with the scheme for reforesting the basin area.

H. S. R. McCurdy, Division Engineer.

May 15, 1920.

LOCKINGTON

On May 8 the fill east of the outlet structure was started by one dredge pump outfit. Since May 18 both units have been discharging continuously onto the east side and good progress is being made.

During the month a pump was put into service for returning to the upper end of the sluice ditch the overflow of the dredge pump sumps, with the ground water from the pit, thus circulating a large volume of water in the sluice ditch. This large flow enables a greater yardage of material to be transported through the sluice than was possible with the smaller stream. The slopes of the sluice ditches have been materially lessened, as a consequence, giving a higher working face, or bank, for obtaining material.

A booster pump has been installed on the monitor pipe line in order to furnish higher pressure when the nozzle is working in those parts of the pit where hard clay banks have to be worked.

The Lidgerwood Class B dragline has finished excavating the cut-off trench of the dam and has been moved into the borrow pit. There it will dig material, principally gravel, which lies below reach of the sluicing operations and place it in a large windrow at a higher elevation, where it can be sluiced to the dredge pumps.

The surfacing of the slopes of the dam with oversize rock, or waste, has kept pace with the fill.

Barton M. Jones, Division Engineer.

May 25, 1920.

TAYLORSVILLE

The dredge pump for the sluicing has been installed at its new location and a booster pump has been added so that sluicing may be started as soon as the B. & O. railroad moves to its new roadway.

The Lidgerwood dragline has been thoroughly overhauled and is moving to the upper end of the inlet channel so that excavation from the inlet channel may be started as soon as sluicing starts. The material dug by the dragline will be cast on the bank to the east and sluiced to the dredge pump.

During the last month the concreting in the outlet works has been moving at slightly better than our scheduled rate. The gravel plant is able to wash and screen the sand and gravel faster than needed for the concrete and the surplus is being stored for use in the main spillway wier, which will be constructed after the gravel plant has been taken down.

The new B. & O. depot at Taylorsville Dam is nearing completion.

Mr. Crampton has started on the construction of the highway from the east end of the dam to the National Road. The present valley crossing of the National Road will be abandoned, the road following the new highway to and across the top of the dam, after the latter is completed.

O. N. Floyd, Division Engineer.

May 25, 1920.

HUFFMAN

A concrete block revetment is being placed along the bank of the outlet channel for a distance of 100 feet below the lower end of the river wall of the concrete outlet structure. This revetment is to protect the bank from wash in time of floods. The blocks used are of solid concrete 1½ ft. by 3 ft. and 1 ft. thick. They are precast at the top of the bank and after sufficient hardening are placed in rows along the bank in brick fashion. The first or bottom row was laid on a solid rock foundation.

The sluicing of material from the hill at the north end of the dam is progressing very satisfactorily. The increase of core material and the resulting decreases in seepage water from the pool have been quite noticeable, since this plant has been in operation.

About 80,000 cubic yards of ballast gravel have been delivered for the railroad relocation work in the Huffman Basin. This ballast gravel is excavated during the day shift and the first half of the night shift. The second half of the night shift is spent in stripping the top soil, this material being pumped into the dam.

C. C. Chambers, Division Engineer.

May 25, 1920.

DAYTON

As noted in the May issue of the "Bulletin," dragline D-15 was damaged and partly submerged during the high water of April 21. The machine will be ready for operation again in a few days. D-16 and D-8 have continued working with scows on the channel excavation above Third Street. D-19 has assisted in the work of repairs to D-15.

The South Robert Boulevard retaining wall is about 67 per cent completed, 2950 cubic yards of concrete having been placed.

To date, 15,080 cubic yards of sand and gravel have been issued from the gravel plant.

Good progress is being made on the revetment construction by Price Brothers Company. The work is now being carried downstream along the easterly bank of Miami River below Herman Avenue.

Channel excavation to date amounts to 802,600 cubic yards. The total pay quantity in spoil banks is 434,000 cubic yards. Levee embankment amounts to 75,500 cubic yards, including 60,000 cubic yards on Contract No. 41. In accomplishing this work, the total yardage handled amounts to 1,380,000 cubic yards. These figures do not include excess excavation for the launching basin and scowing canals which amounts to 77,000 cubic yards.

C. A. Bock, Division Engineer.

May 24, 1920.

HAMILTON

The work was delayed somewhat by the high water of April 19-22. No damage was done to equipment and very little to the completed work.

The electric dragline D-16-18 has passed under the railroad bridge and has started excavating north of same.

The total amount of channel excavation, item 9, to May 1, was 675,300 cubic yards.

Dragline D-16-17 completed the driving of the piling for the northwest wall, then moved to the east side of the river, where it backfilled the northeast wall at the Main Street bridge, and is at present on its way to Black Street.

Concreting is progressing at both the northwest and the southwest walls at the Main Street bridge.

Dragline D-16-20 is building a railroad embankment to connect with the trestle recently completed by Price Bros. Price Bros. have started driving the trestle at Station 110. This work is to provide a track for trains carrying excavated materials from river to spoil bank.

C. H. Eiffert, Division Engineer.

May 20, 1920.

TROY

The spring opening of the work at Troy occurred on March 29, when the dragline commenced excavating again. Frank McGillicuddy & Company arrived on March 23 to open camp and get the dragline in shape for work.

Until April 28 the dragline excavated material from the west side of the cut-off channel and placed it in the levee embankment. On the 28th the dragline rounded the north end of the channel cut and started on a return trip to the down-stream end, excavating the east side of the channel as it goes. Up to date 1150 feet of channel has been completed.

The channel excavation to date amounts to 55,600 cubic yards, 25,250 cubic yards having been placed in levee embankment, of which 2100 feet has been made. The balance of the excavated material has been wasted along the east side of the channel, and on the west side, below the south end of the levee embankment.

The culverts for the two storm water outlets were about two-thirds completed last fall, and the laying of pipe for the same outlets was 50 per cent completed. The culverts are being built by force account, and work on them will be started in the near future.

A. F. Griffin, Assistant Engineer.

May 17, 1920.

LOWER RIVER WORK

Miamisburg—The contractor has not started work with his dragline machine and train outfit, but will probably begin in a few days. He is at present building a trestle along Bear Creek Road at two places where the road will be raised to extend up over the levee.

Franklin—The 400 feet of levee on the west side of the river extending northerly from the suspension bridge is near the point where the levee will cross the River Road and extend westward toward the C. N. R. R. The machine stood on low ground on the river side of the wall just above the suspension bridge during the high water of April 21 and the water rose to within about 3 feet of the roof of the house, but the machine was only slightly damaged.

Middletown—Cole Bros. are completing the levee between Seventh and Eighth streets with the dragline machine. When this is done they will build a trestle along the site of the levee between Fifth and Sixth streets and this levee will be constructed by use of dinkie trains, the cars being loaded with the dragline machine, the material being obtained just below the end of Sixth street and west of the present borrow pit.

The high water of April 21 carried away about 3500 cubic yards of levee material, some of which was in place but not in completed levee.

The C. & C. Haulage Company is making the gravel fill inside the south bank of the hydraulic canal which will widen Hydraulic Street and make room for a wall to be constructed later, thus completing the work between North Main street and the bridge over the M. & E. Canal. They are hauling from the Patterson gravel pit on Poasttown Road, using from two to four trucks, each with a capacity of about five cubic yards loaded by a 5/8 yard steam shovel. The gravel fill is now about 35 per cent complete.

F. G. Blackwell, Assistant Engineer.

May 17, 1920.

RAILWAY RELOCATION

Big Four and Erie—Ballasting on the Big Four and Erie is about fifty per cent complete, the work being done by the Walsh Construction Company. Traffic over the Big Four will be diverted to the new line first, which will take place some time in July.

The signal work is being done by the Big Four forces and they are now working at Tate's Point installing the interlocking system of the B. & O. crossing with the Erie and Big Four Railways.

The right-of-way fence, built by Funderburg Bros. of Fairfield, is practically complete.

The Western Union have the poles all erected and are now stringing the wires.

After the above work is completed there still remains the construction of a station at Fairfield, Ohio.

Baltimore & Ohio Railroad—The Baltimore & Ohio Railroad will probably be operating on the new relocated line when the June Bulletin is published.

Ohio Electric—The District forces are constructing the pole line for the trolley system, the work being about ninety per cent complete.

Albert Larsen, Division Engineer.

May 25, 1920.

RIVER AND WEATHER CONDITIONS

The rainfall over the drainage area of the Miami River during the month of April was greater than during any other April on record, as determined by studies covering the period from 1893 to date. The total for April, 1920, amounted to about 6 inches, or to about twice the average for the period from 1893 to 1919. The maximum for April, prior to 1920, occurred in 1909, amounting to 4.62 inches. Ordinarily the rainfall during April is less than during either March or May. The unusual amount this year was produced by the storm of April 16 to 21, which caused the greatest floods in the valley on record for the month of April, the stage at Dayton reaching 16.2 feet or 1.4 feet higher than any other flood since March, 1913. Rainfall and flood conditions were more severe in the Mad River and Seven Mile Creek valleys than in other parts of the Miami River drainage area.

Observations taken by the U. S. Weather Bureau at Dayton show that the mean temperature for the month was 46.9 degrees or 4.7 degrees less than normal; that there were 3 clear days, 10 partly cloudy days, 17 cloudy days, and 21 days on which the precipitation amounted to 0.01 of an inch or more; that the average wind velocity was 14.1 miles per hour, the prevailing direction being from the southwest; and that the maximum wind velocity for five minutes was 44 miles per hour from the northwest on the 9th.

Ivan E. Houk, District Forecaster.

June 1, 1920.

A Practical Test of the Concrete Revetment

Revetment Edge Drops Eight Feet to Cover Slope of Newly Eroded Channel, the Fabric Remaining Intact.

An important part of the work of the Miami River improvement has been the protection of the banks and levees, at especially vulnerable points, against the scouring action of strong currents during floods, by the use of concrete revetments as an armor covering the earth materials of which the banks and levees are made. The general scheme was described in the Bulletin for August, 1919, page 13, in the article on the River Problem Through Hamilton; the concrete blocks and their manufacture being described in the article immediately following. A cross section of the revetment was shown in the next Bulletin, on page 28. Since those articles were written a considerable frontage of revetment in the city of Dayton, has been put in place, and has been subjected, especially at one particularly vulnerable point, to the action of a flood reaching the 16-foot stage—the highest since the disaster of 1913. An account of what the flood did to the revetment is therefore of considerable interest.

It may be worth while to note that "flexible revetment" as a protection against shore wash is a very old device, woven mattresses of willow withes loaded with basaltic trap rock, and sunk along the shore line, having been used in Holland for a hundred years or more, with excellent results. Similar mattresses, 80 or more feet in width and 500 to 600 feet long, of willow, and similarly loaded and sunk, are used in the standard practice of the United States Government work along the Mississippi and Missouri Rivers. The use of a woven flexible structure of concrete blocks and steel cable or wire, as a substitute in special cases, was a natural development of the other, and seems to have begun about a dozen years ago. It is an interesting point that some of the first as well as most striking and effective work of this kind seems to be due to the Japanese. (See Engineering News, May 16, 1912, and March 13, 1913). Especially on the Ishikari River, where the outer edge of the mattress reached

a depth nearly 40 feet below low water level, this was the case. The behavior of this revetment was noteworthy, as showing the reliability of a flexible concrete revetment under severe conditions.

As explained in the August, 1919 Bulletin the Conservancy revetment is in two main parts—a strip of concrete slabs occupying the lower part of the levee slope, and a strip of smaller concrete blocks laid along the edge of the river channel adjoining the slabs and anchored to them. These blocks are 24″ by 12″ by 5″ in size, and are laid flatwise, and loose, breaking joints like brick in a wall. Steel cable is strung horizontally through holes in the blocks, weaving them into a continuous fabric which is quite flexible, there being no connection between adjacent blocks except the steel cable. The cable is run at right angles to the river bank, and is anchored in the concrete of the slabs on the levee slope, and to heavier, longer blocks which stiffen and strengthen the river edge of the fabric like a garment's hem. At the foot of the levee slope a row of wooden piles is driven, their tops clasped by a low concrete wall built integral with the levee slabs, and to which the flexible fabric is anchored by two cables through every block.

FIG. 143—FINISHED SECTION OF CONCRETE REVETMENT, MAY 26, 1920.
Shows the left bank of the Miami River, in Dayton, below Herman Avenue bridge. Solid concrete slabs 8 feet wide occupy the slope. The flexible mattress of 12 in. by 24 in. concrete blocks, woven together by $\frac{1}{2}$ steel cable, lines the edge of the river bed. See also Figs. 144 and 145.

In flood seasons, such a surface of concrete protects the earth under it, but along the river edge, the scouring action of a swift current tends to undermine it. When this happens, the fabric, being flexible, simply drops to cover the shore side of the excavation made by the current, and thus protect it from further direct action. The result is seen in Fig. 144 and Fig. 145.

The action indicated in these pictures took place at a particularly vulnerable place, just below the Island Park dam, in Dayton. At its east end, this dam abuts upon the levee some distance up the slab slope, as shown in the pictures. The dam crest being level, the result is that at all stages of the river, water at the east end of the dam is pouring in a sheet, thicker or thinner, upon the levee slabs, thence down their slope and across the flexible floor, which also has a slight slope, till it reaches the unprotected river bed, at the lower edge of the mattress. In its rush down the levee slope, it acquires high speed, and strikes the unprotected river gravel like a liquid excavator, or modified "hydraulic monitor," excavating a channel for itself along the edge of the revetment for a considerable distance downstream. (See Fig. 144). The gravel beneath the revetment edge sloughs off into this channel, permitting the lower part of the flexible floor to sink gradually beneath the water surface, and cover the excavated slope.

It is notable that this action, once it has sufficiently deepened the channel next the revetment edge, is self-curing, the water of the deepened channel forming a liquid cushion which stops further destructive erosion of the gravel bottom. The deepest erosion is in fact due to the downstream rush of the water a little further below, for which the action just referred to seems to give an opening wedge. The same cushioning action, however, takes place here also, and the eroded layer rapidly thins out downstream.

Looked at broadly, the function of the concrete revetment, both in its solid slab and its flexible block sections, is like the belt of thickened armor along the water line of a battleship. It protects the vitals of the ship. The top of the levee does not need so expensive a cover. It is protected by grassing, and in case of a threatened breach, is easily reinforced by sandbags and earth. The concrete revetment guards the base of the levee, the foundation of the structure, the vital point, which in case of severe flood will be far below the water surface. Covering this, it takes the stitch in time which saves the more than nine; which mends the incipient breach, closing the wound as soon as formed and presenting a fresh unbroken front just where and when it is needed.

The extent of the erosion which can occur at the

The action of the Island Park dam, seen in the distance at the left, makes this a peculiarly vulnerable place. The water pouring over the end of the dam upon the slab slope, rushes down the latter at high speed, and across the flexible mattress till it strikes the exposed gravel of the channel at the mattress edge, acting upon it as a powerful liquid excavator, undermining the mattress till the latter sinks under the water surface. The channel seen here next the mattress was thus formed, until it attained sufficient depth to protect the gravel bottom against further erosion by forming a liquid cushion to take the impact of the water rushing down the slope. The flexible mattress sank here a maximum of seven feet below its original position, its steel cables keeping its structure intact, to a new position where it now protects the shore slope of the eroded channel from further scouring action. The "hump" in the foreground is caused by heavy boulders which protected the gravel at that point from erosion. It illustrates the flexibility of the mattress in adapting itself to an uneven bottom. This picture was taken before the flood of April 20. Fig. 145 shows what the flood did to the revetment.

FIG. 144—THE FLEXIBLE REVETMENT IN ACTION. MARCH 25, 1920.

[illegible] of the revetment [illegible] will vary considerably with the nature of the material eroded. In the gravel, which constitutes the bed of the Miami River, the shore slope assumed by the erosion is steep, as is plain from the pictures. Measurement showed that in Fig. 144 the river edge of the revetment had dropped about [illegible] feet. [illegible] this drop, came the flood of April 20, and it is gratifying to note that under these severe conditions the additional erosion was only about a foot. The width of revetment provided is sufficient to permit a considerable drop further without danger, the erosion ceasing before the full adaptability of the revetment is exhausted. The stability of the Miami River gravel, together with the ample factor of safety provided for in the design, gives strong assurance of the protection of the levees under maximum flood.

It is believed that at the point where the test occurred the conditions are more severe than anywhere else along the length of the revetment, on ac-

Compare Fig. 144 showing condition previous to that flood. The "hump" referred to persists, but is considerably reduced. Note the slight additional erosion due to the flood. At the right the revetment edge still remains in its original position, although the gravel next to it has been somewhat cut down. The flood reached a stage of 16.1 feet, the highest since 1913. Under the circumstances, and considering the peculiar vulnerability of the levee slope at this point, due to the action of the dam described on page 171, the behavior of the flexible mattress is gratifying to the engineers who designed it, and affords strong reassurance as to its efficiency.

FIG. 145—FLEXIBLE REVETMENT AFTER APRIL FLOOD. MAY 26, 1920.

count of the proximity of the dam creating here a peculiar vulnerability, as explained. The revetment is therefore carried at this point to the full height of the levee. Soundings of the river, after the 1913 flood, established the fact that there is no tendency to the formation of deep eroded pockets along the banks, beyond the now demonstrated ability of the revetment to mend. The worst places are along the west bank just above and below the Dayton View bridge, and at this point the level of the revetment has been lowered in the design to meet these special conditions. It is to be further and especially noted also that at this point, even if undue erosion should occur, it could only do unimportant damage to the immediate bank, for the reason that the shore here is at the foot of a hill. There is no levee at this point, but a steep natural bank.

Nothing has been said so far about the additional factor of protection afforded by the cross-walls. These are of interlocked steel sheet piling, to be driven every 300 feet in the length of the revetment, running crosswise, from the foot of the concrete slab slope half way to the river edge of the flexible block structure, and anchored both to the slabs and to the blocks. This affords additional assurance against any possible undercutting of the levee.

White Iron Centrifugal Pump Shells

Very Heavy Shell of Hard White Iron Expected to Give a Pumping Duty of 40,000 Cubic Yards.

The picture shown in Fig. 150 marks an interesting advance in pumping equipment at the Conservancy dams. In pumping material which contains as much sand and gravel as that placed in the dam embankments, the wear due to attrition of the interior of the pump shells is uncommonly high. A steady stream of sharp particles of quartz and other hard minerals is thrown by the revolving pump runner at high velocities against the interior surface of the shell, causing rapid erosion of the metal. Especially is this true where the metal is ordinary cast iron. For this reason harder compositions have been proposed, and in some cases used, either for the entire shell, or as an interior lining to take the wear.

The first pumps used on the Conservancy work were of cast iron, and showed rapid wear, the pump shell going on the scrap heap after pumping some 160,000 cubic yards of earth. Manganese steel gave improved service, the life of this material in the Englewood dredge pump shells being from 134,000 to 182,000 cubic yards of gritty material pumped. The metal being rather expensive—26 to 27 cents per pound—Mr. Fowler S. Smith, the District's Puchasing Agent, suggested the use of white iron, which is very much cheaper, is at the same time exceedingly hard, and on account of less contraction, can be cast in thicker sections than manganese steel. It seemed to him also that the ability to get replacements of parts in Dayton, where certain firms specialize in white iron castings, would again effect a large saving in shipping charges and expense due to shipping delays. Mr. A. S. Robinson, the District's Mechanical Engineer, and Mr. William McIntosh, its Master Mechanic, had been planning at the same time an improved design giving added life by increasing the shell thickness beyond that possible when manganese steel is used.

One other special feature was made a part of the new pump which, on consideration of all the features mentioned, it was determined to build in the District's own shop. This was the radial reinforcing ribs which show so prominently in Fig. 150. These were originally wrought iron clamps, slipped over the shell to hold the two halves together after they had split in two with excessive wear, the split occurring on the mid line of the steel casting, at its extreme outside rim. By casting the clamps on as ribs to the original casting, they would hold the halves together until the interior wear had gone to such a point as to reach and make holes through the shell rim. Thus the entire thickness of the shell could be utilized before the casting would be discarded.

The patterns were made in the Conservancy shop, on Mr. Robinson's design, the casting being placed in the hands of the Advance Foundry Co. of Dayton, which makes a specialty of white iron castings, in cases where high wearing quality is desired, as in pug mills for clay working, etc.

The first of the resulting pump shells is shown in the figure. The weight of the ribs and flanges may appear excessive in places, but was necessary in order to avoid shrinkage stresses in cooling, which might result in weakness and breakage. The thickness of the shell varies somewhat, being greatest at the rim, where the wear is a maximum, and least on the faces. Imagining the shell seen as a clock face, the extreme thickness, at "6 o'clock," is 5¼ inches. At 8 o'clock it is 5 inches; at 10 o'clock, 4½ inches; at 2 o'clock about 4 inches. On the faces it is about 1½ inches. The pump is a 15-inch pump, absorbing at maximum head 500 horse power and capable of pumping 7,000 gallons per minute at 150 feet maximum head. The flange on the near face is a separate piece, bolted on. The shell proper is machined in only four places—being faced in a lathe on its two faces (to receive the face flanges), on its top (to receive a priming connection) and at the outlet flange face as seen below at the right. (In the picture a reducer connection is shown bolted to the flange.)

The performance of the pump shell to date has been highly satisfactory to those concerned. The pump is installed at the Germantown dam, where it acts as a "booster" in the regular dredge pipe line to the dam top, now 60 feet above the old creek bed. In this capacity, where the wear should be about the same as in the lower pump, it has pumped to date 110,000 cubic yards, wearing away in the performance ¼ inch of shell. Taking into account that the skin of the casting is likely to be somewhat harder than its interior, the builders estimate a probable total pumping duty of about 400,000 cubic yards. This should be contrasted with the 160,000 cubic yards of the gray cast iron shell at Taylorsville dam, and with the 134,000 to 182,000 cubic yards of the manganese steel shells at Englewood. The manganese steel shell at "6 o'clock" was orig-

inally about 2½ inches thick. The cost of the machined white iron casting was 18 cents per pound, as against 26 to 27 cents for the manganese steel, as stated. This relative cost could be reduced in later castings, although market conditions at present would make the actual cost nearer 19 cents for the white cast iron. Further improvements in reducing cost of pump shell wear are in contemplation.

Injured Dayton Dragline Excavator Again at Work

The big Class 175 Bucyrus electric dragline excavator, partially wrecked in the Miami River at Dayton during the flood of April 20, and pictures of which were shown in the last issue of the Bulletin, has been righted, the injured parts restored, and is again at work, none the worse for the experience. The machine is the largest size regularly built by the makers, weighing about 200 tons in working trim. For good reasons, given last month, the flood found the machine a little distance out from the east shore of the river, on its way across, and perched on a built bank of gravel elevated a few feet above low water, in accordance with the method of progression described under Fig. 149. (The machine in Fig. 149 is smaller but of the same general build and appearance as the one wrecked). The river undermined one corner of the machine, swung its revolving frame through nearly 180 degrees, wrecked the 125 foot steel boom by bending it double, and washed some of the mats from under it, leaving it as seen in Fig. 146. About fifty tons of counterweight load the rear end of the frame, to balance the overhang of the boom. Several tons of this counterweight are excess, to balance the pull of the hoist cable, and it is probable that it was the throwing of this excess counterweight into unstable equilibrium as the revolving frame canted under the wash of the current, and its quickening swing to regain equilibrium after passing its high point, that caused the peculiar wrecking of the boom. The position of the wrecked parts indicates this, since the rear (counterweight) end of the frame, which before the flood was downstream, is seen in both pictures pointing upstream, and the wrecked boom, which was pointed upstream, clearly swung downstream and inshore, and apparently broke when the end struck the river bottom. The energy of 80 to 85 tons of metal, revolving on a wide arc, is the only available force which would seem adequate to account for the peculiar damage to the boom.

FIG. 146—WRECKED DAYTON DRAGLINE EXCAVATOR, MAY 12, 1920.

FIG. 147—WRECKED DAYTON DRAGLINE EXCAVATOR, MAY 27, 1920.

The pictures indicate the method of righting and repair. Both are taken from the east

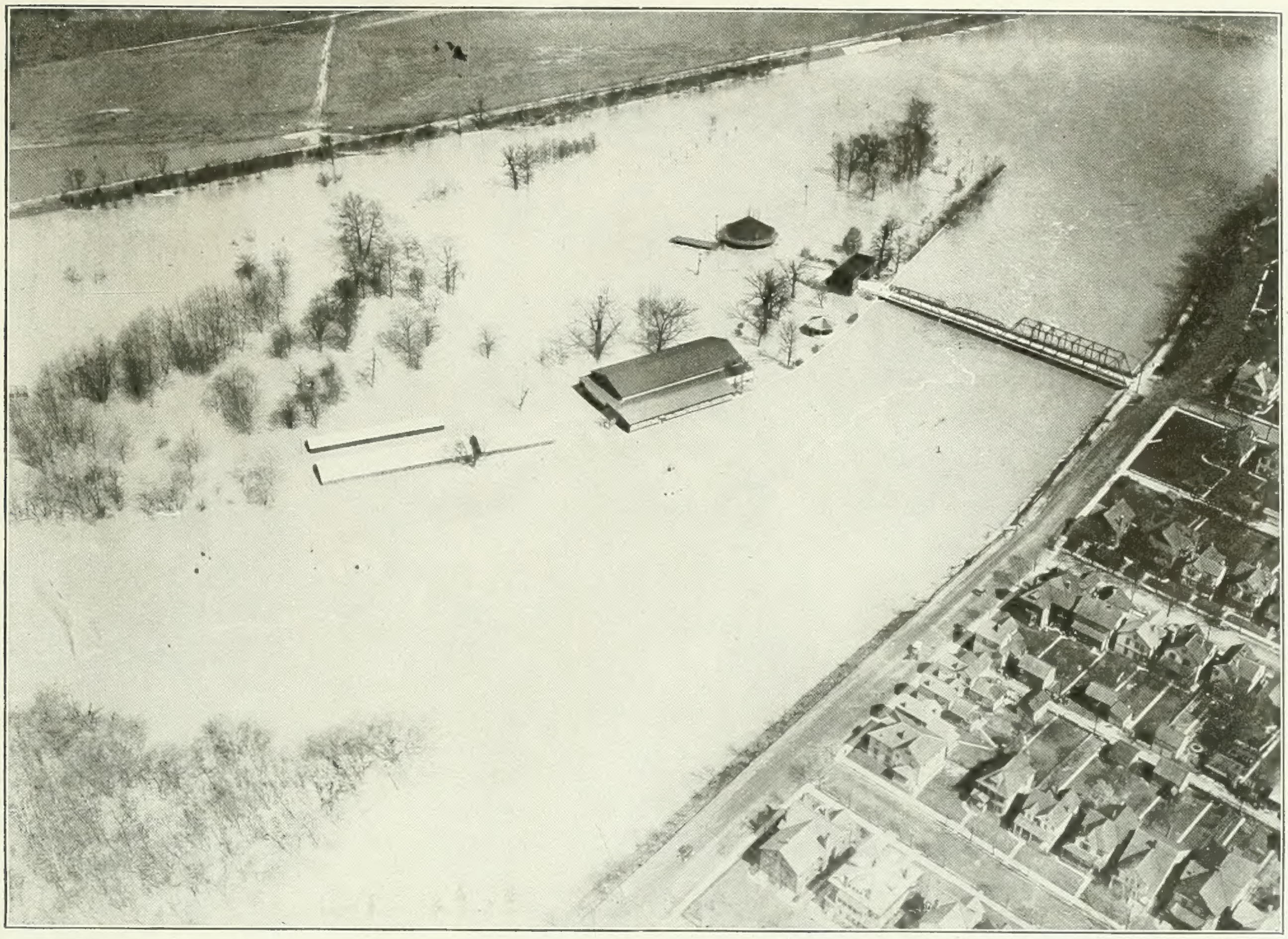

FIG. 148—AIRPLANE VIEW OF FLOOD AT ISLAND PARK, DAYTON, APRIL 21, 1920.

bank of the river. In both pictures parts of a smaller dragline appear used in the work. The wrecked dragline is seen enclosed by an embankment of earth built around it from the east bank by the smaller machine. The water in the enclosure was then pumped out, the pipe at the right in Fig. 146, hanging by chains, being the suction pipe of the centrifugal pump which did this work. The chains hang from the dragline bucket, the small machine acting as a wrecking crane as well as an excavator. In Fig. 147 the little machine is removing the pieces of the wrecked boom, which were taken to the Conservancy shop on 7-ton trucks, and there repaired. The wrecked dragline was righted by digging away the river bed from beneath the high corner (using the small excavator for this purpose), and then building up under the low corner with timber work as seen in Fig. 147, the lifting being done by powerful jacks. The fifty tons of counterweight were, of course, removed before the raising, and replaced after the wheel trucks on which the machine rolls were once more in position on their rails and "mats." The chief injury, next to the broken boom, was the breakage of the large propelling shaft under the middle of the revolving frame. A spare shaft was in readiness, so that there was no delay on this account. The electric motors, which supply all motive power, were under water during the flood. They were wiped clean, and dried by running a low voltage current through the coils, the heat generated by the current being quite sufficient for this purpose. The connections for accomplishing this, which may interest the electrical fraternity, are given in the editorial column.

The machine was again in working order, and began "digging itself out" on June 3.

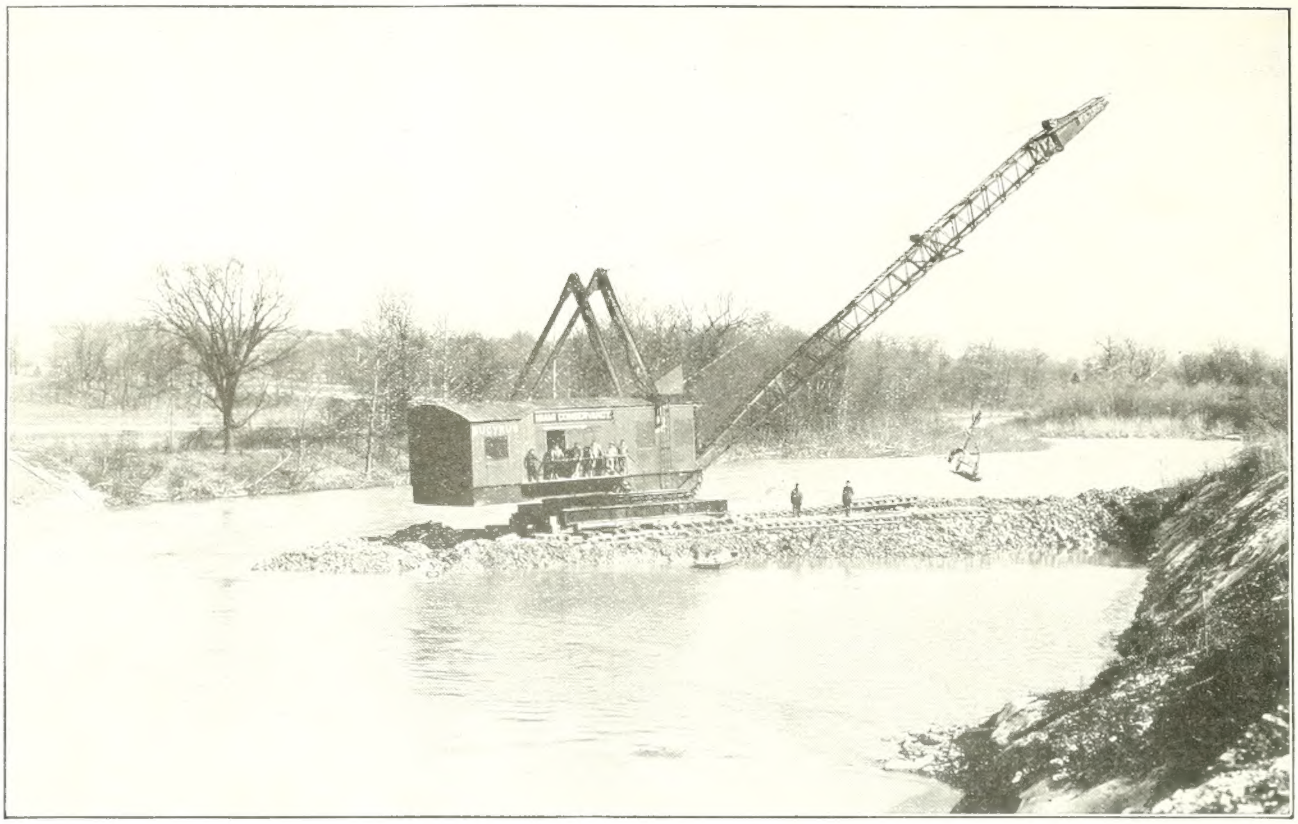

FIG. 149—DRAGLINE EXCAVATOR CROSSING STILLWATER RIVER AT ENGLEWOOD. MARCH 3, 1920.

The crossing began at the farther shore by building out a peninsula of river gravel for the dragline to roll forward on, this work being done by the excavator bucket. The machine then rolled onto the peninsula, and made an island of it by cutting off its "neck," placing the excavated material on ahead. Carrying thus its island with it, by picking it up in the rear and placing the material in front, it crossed the stream, the island ultimately becoming once more a peninsula by joining the nearer shore. The picture is taken at this stage of the proceedings. On reaching shore, the dragline began its work of excavating a temporary spillway parallel to the river, preparatory to building the river section of the dam embankment.

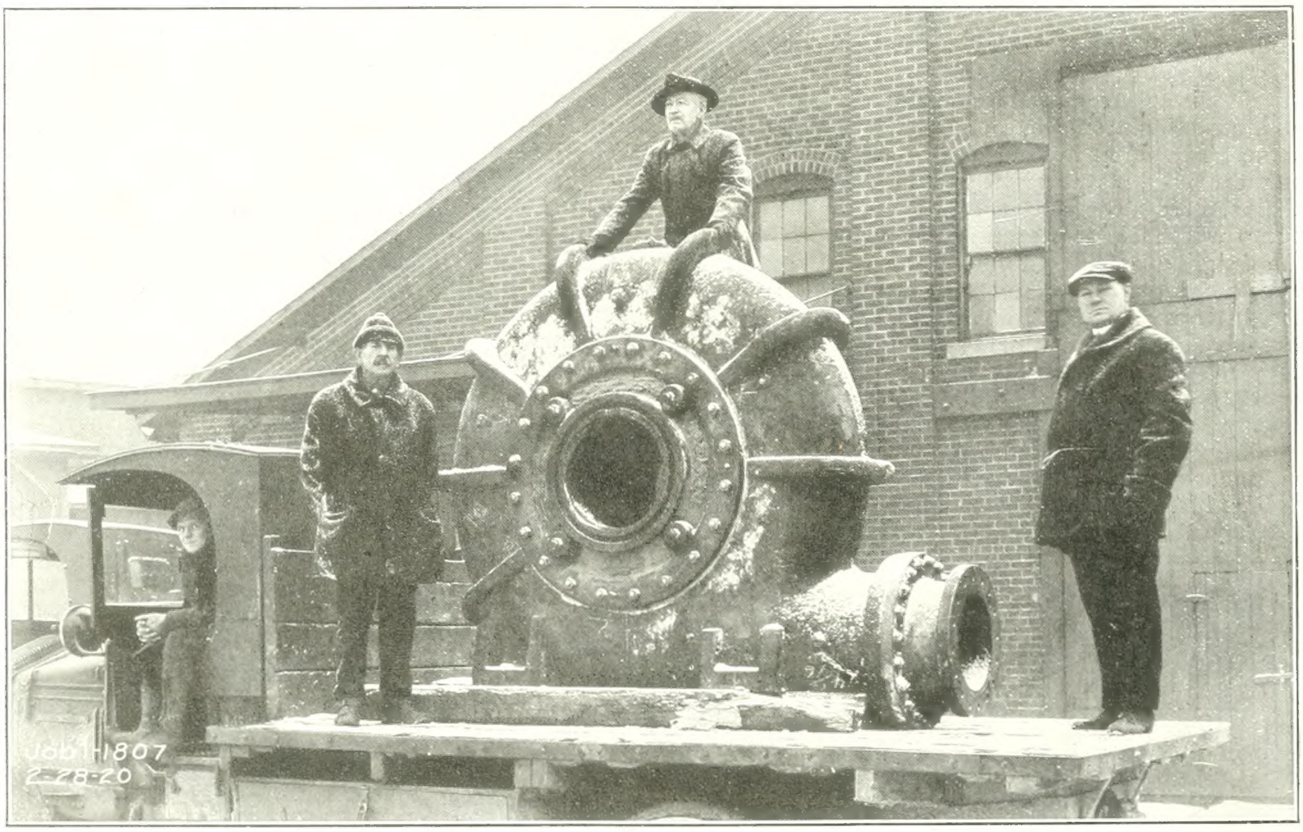

FIG. 150—HEAVY WHITE IRON CENTRIFUGAL PUMP SHELL. FEBRUARY 28, 1920.